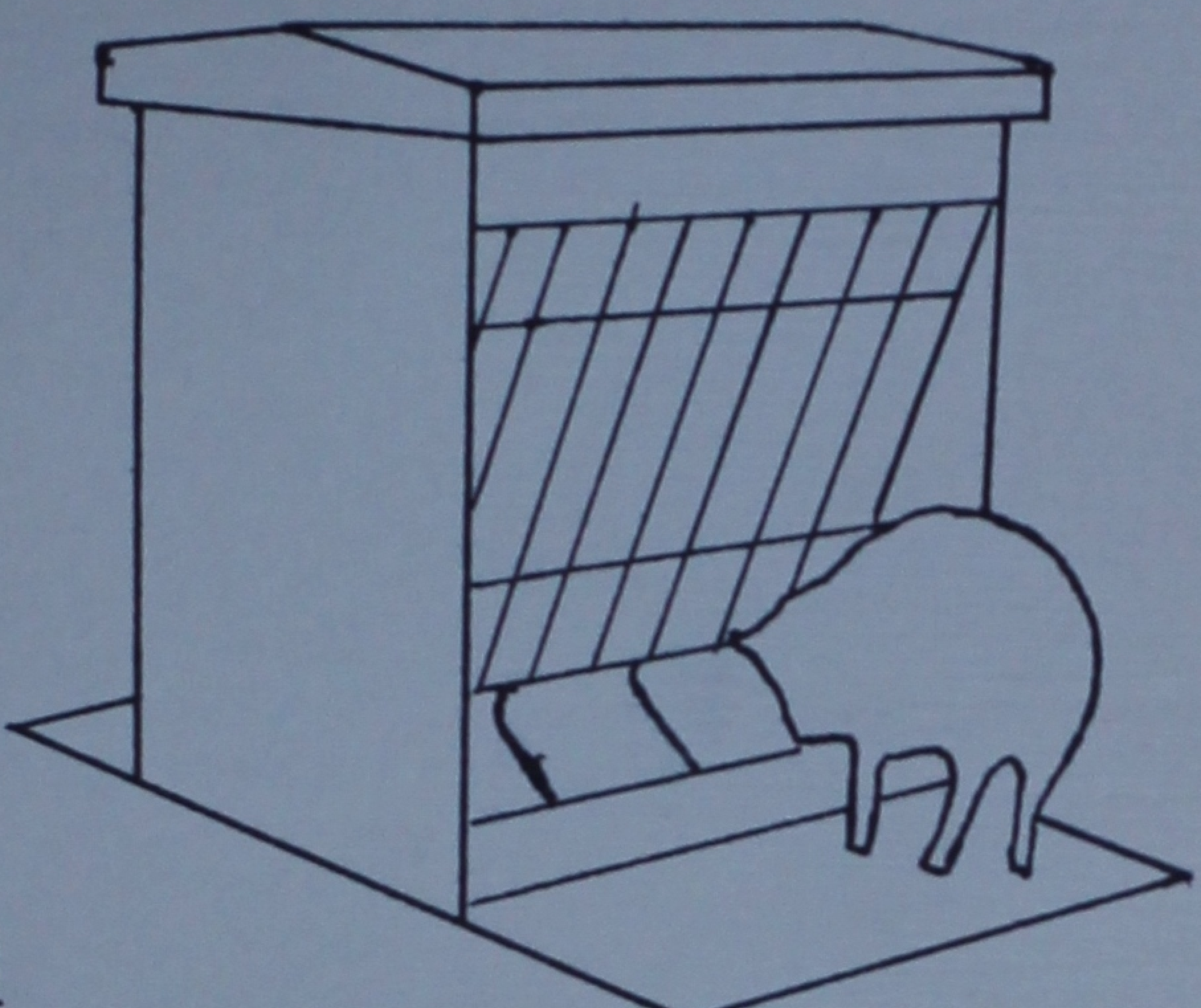
# A PORTABLE HOG FEEDER





# from RED OAK LUMBER

James T. Micklewright



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*JAMES T. MICKLEWRIGHT began his forest products technology career in 1952 at the U. S. Forest Products Laboratory where he worked in the Division of Material Containers. After a year he moved to the Timber Engineering Company Research Laboratory in Washington, D. C. as a Wood Technologist. In 1955 Jim returned to the Forest Service, this time conducting secondary wood utilization research at the Central States Forest Experiment Station's branch in Carbondale, Illinois. It was there that the research leading to this publication was done. Since 1963 Micklewright has been a Forest Products Technologist in the Forest Products Marketing Branch of the Division of Forest Economics and Marketing Research in Washington, D. C. Jim graduated in forestry from Iowa State College and had special training at the Timber Engineering Company Research Laboratory under a scholarship granted by the National Lumber Manufacturers Association. He is a member of the Alpha Zeta Agriculture Honor Society, Gamma Sigma Delta Agriculture Honor Society, and Phi Kappa Phi National Scholastic Honor Society.*

Central States Forest Experiment Station, U.S. Dept. of Agriculture
Forest Service, 111 Old Federal Building, Columbus, Ohio 43215
R. D. Lane, Director

# ACKNOWLEDGMENT

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## SUMMARY

*Hog feeders were produced from No. 1 Common, No. 2 Common, and No. 3 Common red oak lumber, and from C and Better Douglas-fir Finish lumber, which is commonly used for these products. Production of 210 feeders from about 56,500 board feet of lumber showed that, despite lower yields and higher investment, labor, and overhead costs, feeders can be produced at less cost from all grades of oak lumber studied than from the higher priced, high-grade Douglas-fir lumber. Those who are concerned with the problem of marketing No. 2 Common and Poorer grades of hardwood lumber would do well to look to hog feeders and similar small farm structures as possible uses for this material.*

# A PORTABLE HOG FEEDER from RED OAK LUMBER

New uses are needed for low-quality hardwood timber. Hardwood forests of the Central States are producing more than twice as much wood as is being cut each year. But only about 25 percent of the volume of these forests is top grade. To provide growing space for better trees forest managers must get low-quality trees out of the woods. But this cannot be done unless material cut can be profitably utilized. The solution probably lies in expanded markets for pulpwood, chemical wood, and other bulk material. But new and better ways to use low-grade lumber are also needed. Even the best hardwood saw logs yield some No. 2 Common and Poorer grade boards, so hardwood sawmills will always produce some low-grade lumber. Profitable outlets for this material should help more of today's mills stay in business and assist in upgrading forest resources.

Many million board feet of lumber are used annually in the Central States area to produce small, portable farm structures. An estimated 27 million board feet were used in Iowa in 1955 to manufacture portable hog houses, hog feeders, cattle feeders, brooder houses, grain bins, and other structures. All of this was softwood; most of it was shipped into Iowa from the West. Besides lumber used by industry, many million feet were undoubtedly used by farmers or contractors to build farm structures for themselves or on special order. This farm use was estimated to be 150 million board feet for Illinois in 1955. We believe that similar situations exist in the other midwestern states and that wood used in small farm structures is a large part of the total wood used in the area.

Many of these structures can be made from short-length parts; and small tight knots, surface checks, and similar minor defects could be permitted in most parts. Since they are used outdoors, these structures can be made of air-dried lumber. Because they are relatively simple in design, they lend themselves to production in small shops equipped with only basic woodworking machinery. All of these factors point favorably to producing small farm structures from the lower grades of hardwood lumber in existing plants or in small shops set up in conjunction with existing sawmills for this purpose. Yet the 1955 study in Iowa and our observation of products from other midwestern states show that nearly all commercially built small farm structures are made of high-grade softwood lumber.

Hog feeders seem to be especially suited to production from low-grade hardwood lumber because of their design and the variety of sizes produced. At least eight plants in the Central States area are now producing feeders from softwoods. All that we have seen are made of Select Grade Finish lumber. The relatively high cost of these commercial wooden feeders encourages competition from lower priced, less durable metal feeders. So any reduction in the cost of wooden feeders should help preserve and perhaps increase this market for wood. Manufacturers consulted said they would welcome reduced lumber costs. But they believed that higher investment, labor, and overhead costs, and machining and nailing difficulties would preclude any advantage from using lower cost, low-grade hardwood lumber.

This report shows that a high-quality portable self-feeder for hogs can be produced at lower cost from lower grades of red oak lumber than from high-grade softwood lumber. Work was carried out at our Wood Products Pilot Plant at Carbondale, Illinois. Several native hardwood species can probably be used in products of this type. We used red oak because it is most plentiful in Central States woodlands and constitutes the bulk of material for which markets are needed. We used C and Better Douglas-fir Finish lumber for softwood feeders because it is most commonly used by the industry and, thus, forms a basis for cost comparison.

# WHAT WE DID

Our first step was to consult animal husbandrymen and agricultural engineers in the Midwest. Also, we examined several different commercial softwood hog feeders. We then designed a hardwood feeder around the properties of red oak lumber (fig. 1). This feeder is similar to several softwood feeders now on the market. The main differences are that we added thick, longitudinal structural members to the sides and installed side sheathing vertically instead of horizontally. This reduces the length of side sheathing and favors utilization of lower grades of lumber. Because oak is stronger than softwoods and holds nails better, we also reduced the thickness of hardwood feeder parts. Nominal 3/4 (S2S to 9/16 inch) and 6/4 (S2S to 1 5/16 inches) lumber was used in hardwood feeders instead of nominal 4/4 and 8/4 lumber used in softwood feeders. As a result, our 6-foot feeder is only about 9 percent heavier (435 pounds total) than the average softwood feeder of the same size and capacity.

We built a prototype oak hog feeder and tried it out at the Southern Illinois University swine farm. After a few minor modifications in design and some preliminary production trials, we began our production study. We produced two sizes of feeders from three different grades or grade combinations of commercial red oak lumber by three different production methods. For comparison, we also built feeders of both sizes by conventional methods from the grade of Douglas-fir lumber commonly used. Of 210 feeders produced, 180 were oak and 30 Douglas-fir. Production runs were replicated in lots of five feeders each.

*FIGURE 1.—A 4-foot, red oak hog feeder in use on the Southern Illinois University swine farm.*

### *SIZES OF FEEDERS*

We made 6-foot, 12-door feeders and 4-foot, 8-door feeders of identical design except for length. The 6-foot feeders hold about 26 bushels of feed and 4-foot feeders about 17 bushels. Because 6-foot feeders are most popular, they were produced by all three methods. The 4-foot feeders were produced by only one method to learn how feeder size affects yield of parts (some 4-foot feeder parts were shorter in length). As mentioned, Douglas-fir feeders differed from oak feeders only in thickness of parts.

## *GRADES OF LUMBER*

Oak feeders were produced from No. 1 Common, No. 2 Common, and a mixture of No. 2 Common and No. 3 Common random width, random length, rough, factory lumber. [1], [2] (Hereafter the mixture of No. 2 and No. 3 Common is referred to as No. 2 Common and Poorer.) The mixture was approximately 30 percent No. 2 Common and 70 percent No. 3 Common. Amounts of each grade were chosen on the basis of a preliminary study in which feeder parts were diagrammed on sample boards of these two grades.

Grademarked[3] S4S Douglas-fir lumber was used in softwood feeders as follows:

8/4, S4S parts — C and Better — Flat Grain Finish

4/4, S4S parts — C and Better — Flat Grain Finish

4/4, Sheathing — C and Better — Flat Grain Car Siding (Pattern No. 116)

8/4, Flooring — C and Better — Tongue and groove

16/4, S4S parts — C and Better

Douglas-fir lumber was ordered to specified lengths for specific feeder parts to minimize waste in crosscutting.

All oak lumber was air-dried to 12- to 14-percent moisture content. Douglas-fir lumber, with the exception of the "green" 16/4 material, was purchased kiln-dried.

## *PRODUCTION METHODS*

Six-foot oak feeders were produced by three methods that differed in degree of mechanization. Only one method (method B) was used for 4-foot oak feeders. Douglas-fir feeders were produced by methods currently used in the industry.

Machinery and equipment used in the different methods are listed in the Appendix, on page 31. Method A was our "small shop" method. Here we used what we believe is the minimum equipment required to produce feeders from oak lumber. All machines except those normally equipped with mechanical feed works were manually operated and hand-fed. Operations such as crosscutting, planing, and ripping were performed individually and material was moved from one operation to the next on

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[1] *National Hardwood Lumber Association grades as described in Rules for the Measurement and Inspection of Hardwood Lumber, National Hardwood Lumber Association, Chicago, Illinois, 124 pp. 1958.*

[2] *Two parts of the feeder, the skids and the trough fronts, were produced separately and were made the same for all feeders regardless of grade of raw material or production method.*

*Boards 6 feet or 12 feet long and either 4, 8, or 12 inches wide were picked from No. 2 Common red oak lumber and machined into skids. These were sent to a local plant to be pressure treated with pentachlorophenol. These oak skids were also used on the Douglas-fir feeders.*

*Trough fronts were made from 4- by 4-inch mill-run oak or C and Better Grade Douglas-fir. Production consisted of squaring up the 4 by 4 on a hand jointer and planer, and then ripping it in two on a band saw diagonally along its length.*

[3] *West Coast Lumbermen's Association. Standard grading and dressing rules. Portland, Oregon, 338 pp., illus. 1956.*

factory trucks or skids. Most operations were performed by two men—an operator and an off-bearer or tailer (fig. 2). Rough parts were sorted by length at the crosscut operation. Then the material was surfaced on two sides in two passes through a single-surface planer and taken to the ripsaw. Tongue-and-groove sheathing and flooring were produced on a single-spindle shaper. Two passes were required, one for the tongue and one for the groove, and the material was hand-fed to an off-bearer.

parts onto factory trucks by length. Parts were then taken to the ripsaw as in method A. Tongue and grooving was again done by two men on a single-spindle shaper, but a power feed unit was mounted on this machine to assist in the feeding (fig. 4).

Rough-milling in method C was similar to that in method B except that surfaced cuttings were taken from the single surfacer to two straight-line ripsaws by a belt conveyor (fig 5). Each ripsaw was equipped with a crossfeed "tailboy"

*FIGURE 2.—Crosscutting rough lumber to length on a swinging cutoff saw as in a small shop (method A).*

In method B, a hydraulically operated cutoff saw was used for crosscutting in place of a manually operated swing cutoff saw. The off-bearer was replaced by a live-roll conveyor that carried rough parts to a facing planer where they were surfaced on the underside (fig. 3). A belt conveyor carried the parts from the facing planer to a single-surface planer which surfaced them on the top side to finished thickness. An off-bearer at the outfeed end of the single surfacer sorted

conveyor that carried ripped cuttings back to the main belt. The main belt deposited the parts onto a revolving sorting table from which they were sorted onto factory trucks by length. Thus, in method C, the crosscutting, surfacing, ripping, and sorting operations were performed simultaneously by four men. A 4- by 8-inch high-speed moulder was used to tongue and groove the sheathing and flooring.

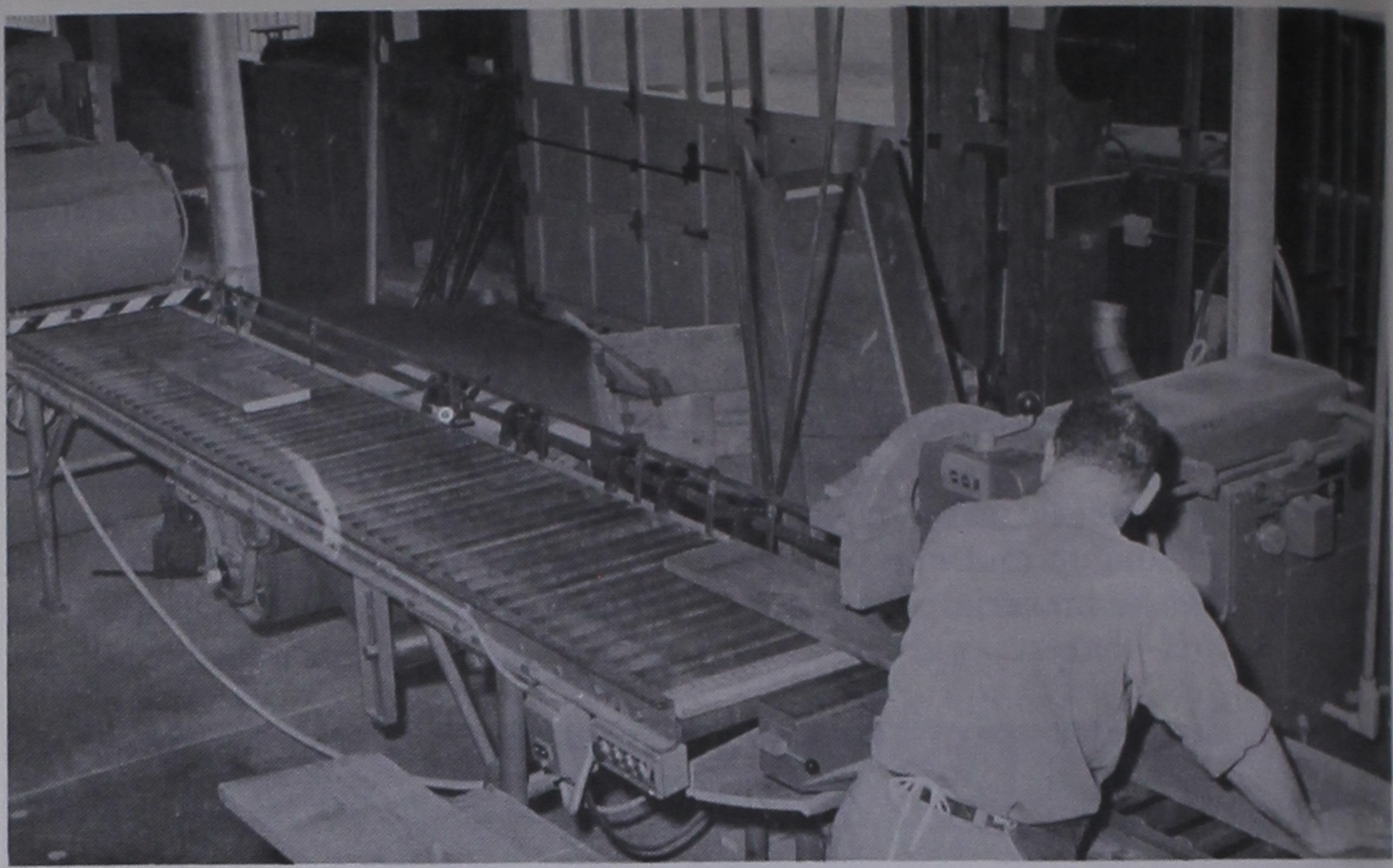

*FIGURE 3.—Hydraulic cutoff saw, live-roll conveyor, and facing planer used in method B.*

*FIGURE 4.—Tongue-and-grooving hog feeder sheathing on a shaper with power feed.*

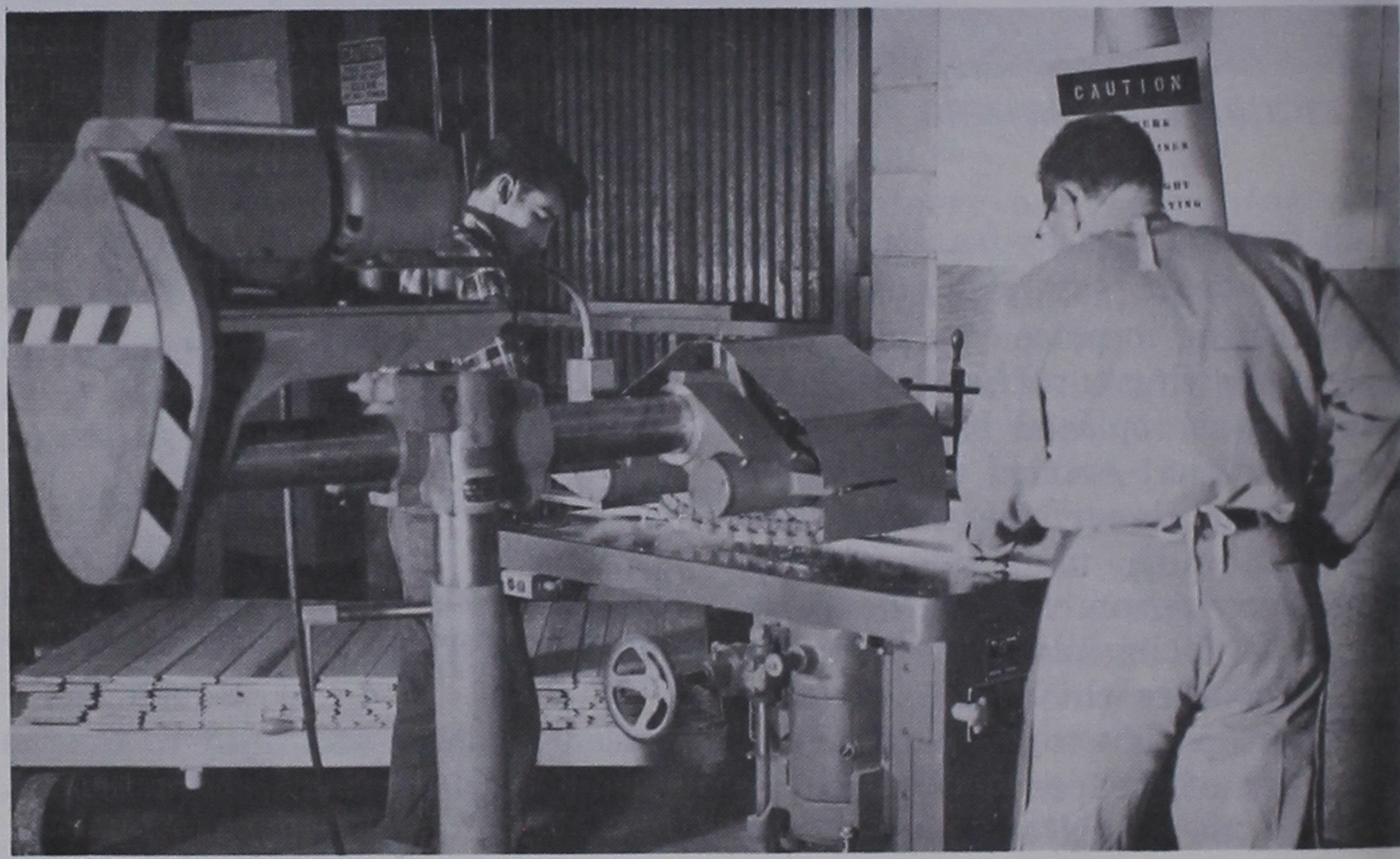

*FIGURE 5.—Ripping operation from outfeed end of surfacer showing two ripsaws with tailboys, belt conveyor, and sorting table.*

In all three production methods and for both sizes of feeders, rough oak lumber was first sorted into rip- and crosscut-type boards. Sorting was done on the basis of width, warp, and position of defects. The rip-type boards were ripped and combined with the crosscut-type boards at the cutoff saw. The cutoff sawyer then crosscut the lumber for maximum yield of the longest and widest parts required (see bill of materials and specifications of finished parts, Appendix, pages 32 and 33). The sorter notified the sawyer when the quota of any one part was obtained and the sawyer then quit cutting that part. This procedure was continued until the quota of all parts for the lot was filled.

All parts were crosscut ½ to ¾ inch oversize in length in the rough-mill and later trimmed to exact length. Fixed-width parts were ripped to finished width in the rough-mill. All sheathing and flooring was ripped to random widths of 2 to 6 inches. In methods A and B it was possible to tongue and groove true random width sheathing and flooring. But in method C this material was sorted into ½-inch-width classes that were fed separately to the moulder.

Except for the tongue and grooving, all finish-mill operations (e.g., angle cutting, dadoing, notching, boring, and trimming), panel fabrication, and feeder assembly were the same for all production methods and for both sizes of oak feeders. Where two or more methods seemed practical for performing a given operation, each method was tried on a few feeder parts. Then the most efficient method was used on the remainder of the parts.

Milling of Douglas-fir feeder parts consisted of crosscutting the dressed lumber to length on a manually operated radial-arm saw and ripping some 2- by 6-inch lumber into 2- by 3-inch structural members. Parts for 6-foot and 4-foot feeders were produced simultaneously. From this point on, Douglas-fir feeder parts were machined and handled the same as oak parts.

After all machining was completed, parts were fabricated into feeder bases, sides, ends, partitions, and roofs in sturdy jigs constructed for this purpose (figs. 6 and 7). Bolt holes were drilled with portable equipment during panel fabrication. In fabricating panels, all parts were hand nailed without predrilling. After trying common wire nails and various types and sizes of deformed nails, we selected the following nails for use in the feeders:

| *For nailing* | *We used* |
|---|---|
| Nominal 3/4 material to nominal 3/4 material | 1⅛-inch, 16-gauge, hardened, spiral-thread, blunt-diamond-point, galvanized nails |
| Nominal 3/4 material to nominal 6/4 material | 1½-inch, 14-gauge, hardened, spiral-thread, blunt-diamond-point, galvanized nails |
| Nominal 6/4 material to nomial 6/4 or heavier material | 7d, hardened, spiral-thread, blunt-point, galvanized, flooring nails |
| Galvanized-steel roof and trim to wood frames | ½-inch, 14-gauge, spiral-thread, diamond-point, cadmium-plated nails |

*FIGURE 6.—Nailing a side panel for a 6-foot oak feeder.*

*FIGURE 7.—One man drills holes in completed side panel while the other fastens cleats for locating partitions.*

One exception to this nailing schedule was made: For side panels, nominal 3/4 sheathing was nailed to nominal 6/4 structural members with 4d common wire nails. In this application the nails were located far enough from the ends of the sheathing to minimize splitting. Nominal 4/4 and 8/4 Douglas-fir parts were nailed the same as were 3/4 and 6/4 oak.

Prefabricated panels and other wood parts were treated with a 5-percent solution of pentachlorophenol in mineral spirits before final assembly. Feeder bases (skids, flooring, and trough fronts) were soaked a minimum of 24 hours. All other parts were dipped 3 to 5 minutes.

After treated parts had dried enough for safe handling, the feeders were assembled (figs. 8, 9, and 10). They were then finished by spraying with one coat of Forest Products Laboratory natural finish[4] containing 3 pints of red iron-oxide pigment to 5 gallons of finish.

All operations, from sorting and crosscutting of rough lumber through assembly and finishing of the feeders, were timed to the nearest 0.01 minute, and the input (volume, number of pieces, etc.) and output of each operation were measured to determine the direct labor and materials required to produce feeders.

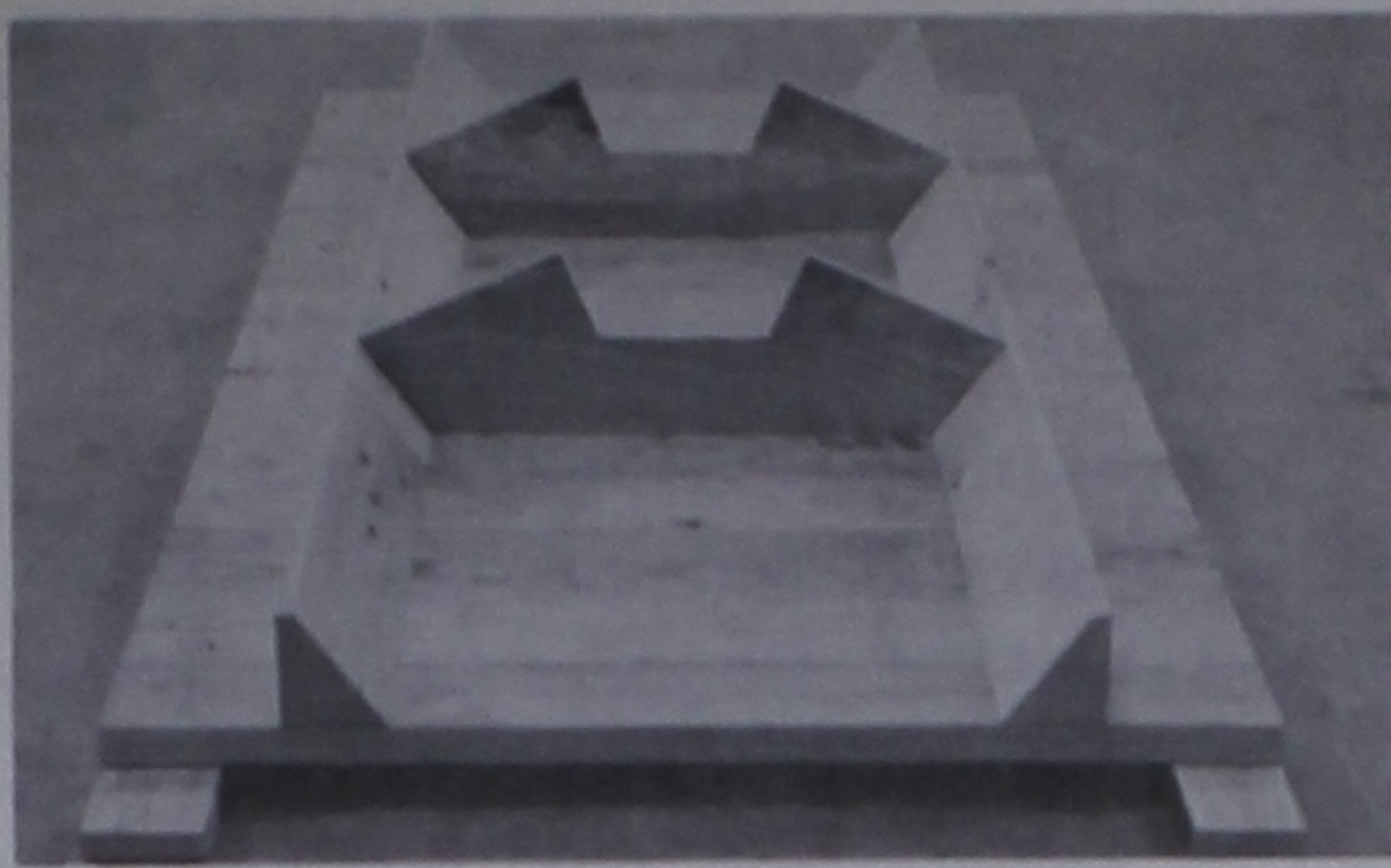

*FIGURE 8.— A feeder base with trough fronts and separators in place ready for attachment of ends.*

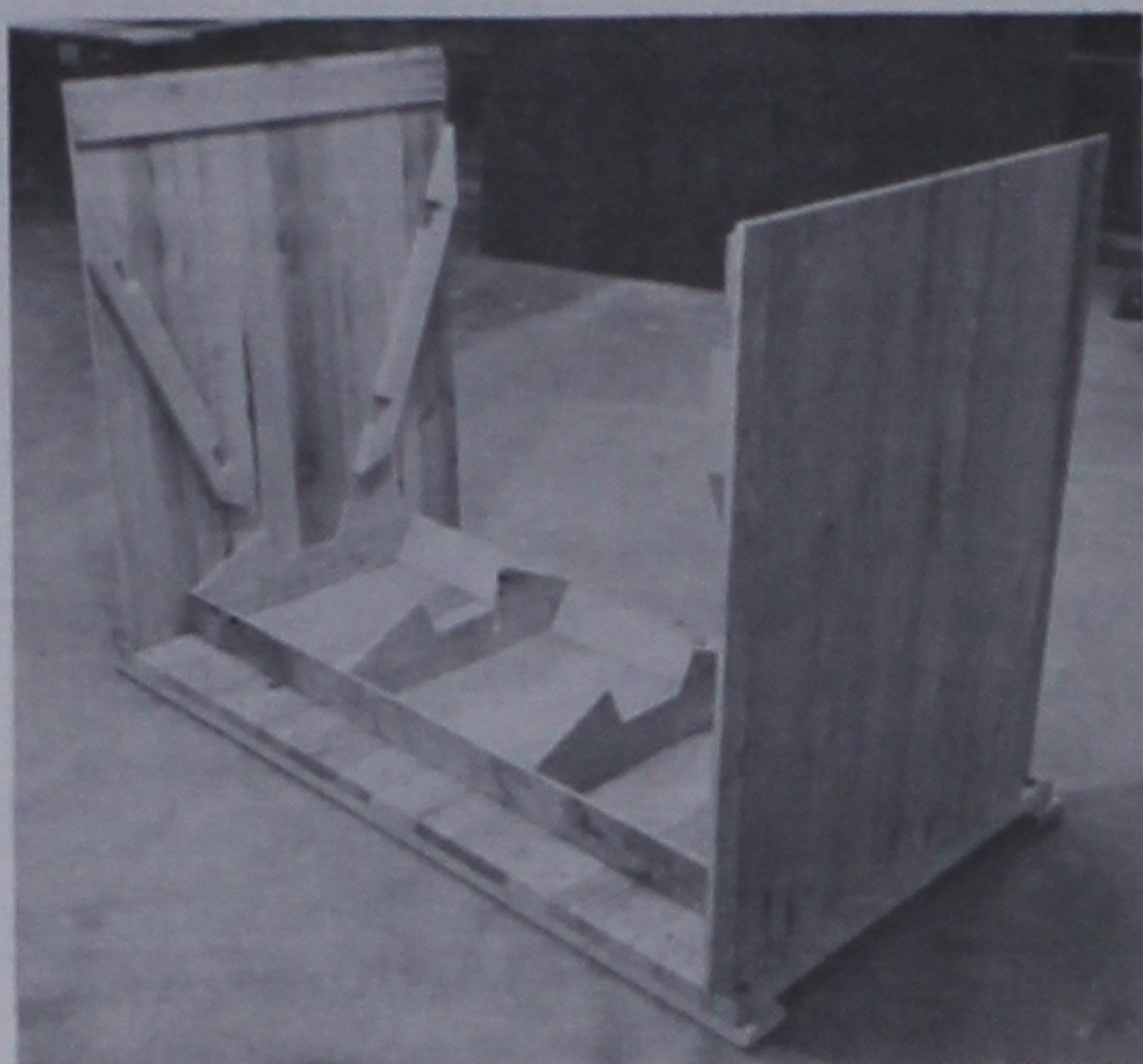

*FIGURE 9.— End panels attached to the feeder base.*

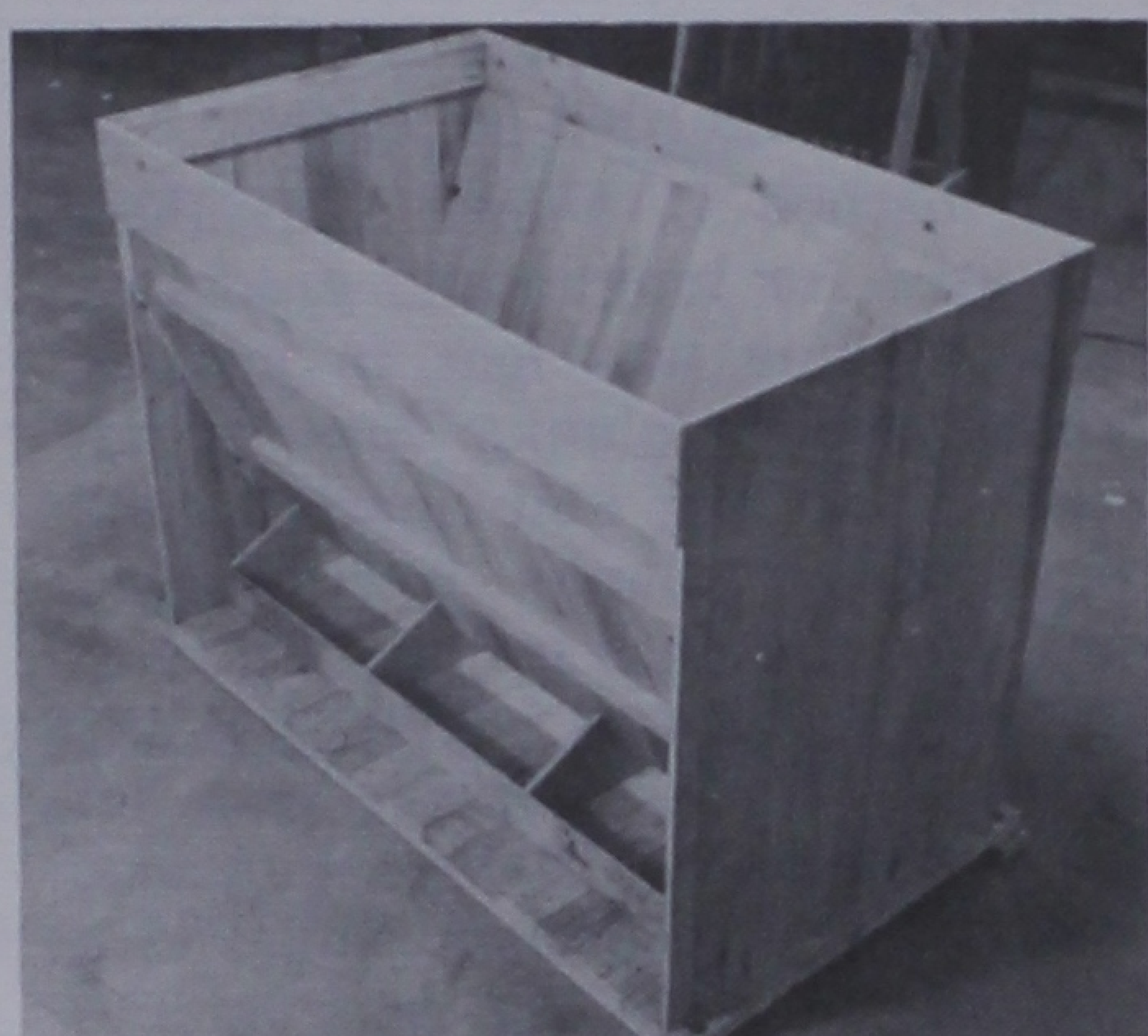

*FIGURE 10.— Assembled base, ends, and sides, ready for attachment of metal parts.*

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[4] *U. S. Department of Agriculture, Forest Service, Forest Products Laboratory natural finish. Forest Prod. Lab. Rpt. 2096, 3 pp., illus. 1961.*

# WHAT WE FOUND

## *YIELD OF FEEDER PARTS*

Approximately 51,000 board feet of commercial red oak and 5,400 board feet of Douglas-fir lumber were used in this study. Yield of feeder parts from oak lumber of each grade was not affected by method of rough-milling or size of feeder (table 1). However, yield of parts for both sizes of oak feeders was affected by grade of lumber used, and yield from high-quality Douglas-fir lumber was much greater than from any grade of oak.

In crosscutting 3/4 oak lumber for feeder parts, we first took all available fixed-length parts from a board. Any short material (down to 14 inches in length) that was left was processed into random-length sheathing for feeder partitions. The lower grades of oak lumber yielded an excess of this short, random-length material; any that was left after partition panels were fabricated was regarded as waste.

In method C, where a moulder was used for tongue and grooving, some volume was lost in cutting random-width blanks into fixed-width sheathing and flooring (the rough-milled blanks were sorted into ½-inch-width groups, e.g. 3 to 3½ inches, 3½ to 4 inches, 4 to 4½ inches; and the moulder was set for 3 inches, 3½ inches, 4 inches, and so on). In methods A and B, a shaper was used for tongue and grooving and there was no loss in width of parts.

Yields by lumber grade (table 1) are based on the rough dimensions of usable oak parts and nominal dimensions of Douglas-fir parts produced in the rough-mill. The yields were adjusted for overrun of partition sheathing, loss in moulding (method C), and loss from rejects during finish-milling and assembly. The average yield of all feeder parts except skids and trough fronts was about 70 percent from No. 1 Common oak, 60 percent from No. 2 Common oak, 48 percent from No. 2 Common and Poorer oak, and 92 percent from C and Better Douglas-fir.

Yields from No. 2 Common and Poorer oak lumber appear to be abnormally high for 6-foot feeders in method C, and for the 4-foot feeders (method B). We believe this was due to an upgrading of the No. 3 Common lumber in the No. 2 Common and Poorer oak as the study progressed. Method A was run first and was followed by methods B and C. The 4-foot oak feeders were produced last. As lumber was graded and sorted for the early production runs, some boards were downgraded because of seasoning checks, pinholes, and other minor defects that are not objectionable in feeder parts. Thus, even though the mixture of No. 2 Common (30 percent) and No. 3 Common (70 percent) was held constant, the No. 3 Common lumber used in later production runs was probably of better quality than that used in earlier runs.

*TABLE 1.—Yield of feeder parts by feeder size, production method, and lumber species and grade*[1]

(In percent)

| Grade and species | Thickness | Oak feeders: 6-foot: Method A | Oak feeders: 6-foot: Method B | Oak feeders: 6-foot: Method C | Oak feeders: 6-foot: Average | Oak feeders: 4-foot | Douglas-fir feeders: 6-foot | Douglas-fir feeders: 4-foot |
|---|---|---|---|---|---|---|---|---|
| No. 1 Common oak | 3/4 | 76.1 | 68.3 | 70.0 | 71.4 | 70.6 | | |
| | 6/4 | 70.6 | 68.4 | 65.6 | 68.2 | 64.5 | | |
| | All | 74.1 | 68.4 | 68.5 | 70.3 | 68.6 | | |
| No. 2 Common oak | 3/4 | 60.0 | 63.0 | 57.1 | 60.0 | 58.8 | | |
| | 6/4 | 63.8 | 60.3 | 57.4 | 60.3 | 52.0 | | |
| | All | 61.2 | 62.1 | 57.2 | 60.1 | 56.5 | | |
| No. 2 Common and Poorer oak | 3/4 | 44.9 | 42.4 | 52.2 | 46.4 | 52.3 | | |
| | 6/4 | 48.2 | 45.3 | 56.0 | 50.1 | 48.4 | | |
| | All | 46.0 | 43.3 | 53.5 | 47.7 | 50.9 | | |
| C and Better Douglas-fir 2/ | 4/4 | | | | | | 93.2 | 93.2 |
| | 8/4 | | | | | | 89.8 | 89.8 |
| | All | | | | | | 91.9 | 91.9 |
| No. 2 Common oak (skids) 3/ | 6/4 | | | | 72.8 | 72.8 | 72.8 | 72.8 |
| Mill-run oak (trough fronts) 4/ | 16/4 | | | | 55.8 | 55.8 | | |
| C and Better Douglas-fir (trough fronts) 4/ | 16/4 | | | | | | 87.5 | 87.5 |

1/ Yield of cuttings from rough-mill, adjusted for overrun of partition sheathing, finish-mill rejects, and loss in moulding. Each yield figure is the average of three replications.

2/ Parts for 6-foot and 4-foot Douglas-fir feeders were produced simultaneously.

3/ Skids were cut separately from all other 6/4 parts. Two sizes were produced simultaneously and oak skids were used on all feeders.

4/ Trough fronts were produced separately from 4- by 4-inch lumber. Two sizes were produced simultaneously from both oak and Douglas-fir lumber.

The effect of this upgrading of No. 3 Common lumber is reflected, also, in the time required to rough-mill the No. 2 Common and Poorer lumber for 6-foot feeders in method C, and for the 4-foot oak feeders (table 2). Crosscutting and surfacing were done the same in methods B and C, but the time per feeder for No. 2 Common and Poorer lumber in method C is substantially less since yield was greater and work per feeder was less.

Skids for all feeders were produced at the same time from No. 2 Common 6/4 oak lumber selected for length and width. Those for 6- and 4-foot feeders were cut simultaneously and the yield was 73 percent.

Trough fronts were produced from mill-run oak and C and Better Douglas-fir 4- by 4-inch timbers. Parts for both sizes of feeders were cut simultaneously and yield was 56 percent from the oak and 88 percent from the Douglas-fir lumber.

*TABLE 2.—Labor time for rough-milling and tongue-and-grooving feeder parts by feeder size, production method, and lumber species and grade*[1]

(In man-minutes per feeder)

| Operation | Grade of lumber | Oak feeders: 6-foot: Method A | Oak feeders: 6-foot: Method B | Oak feeders: 6-foot: Method C | Oak feeders: 4-foot 2/ | Douglas-fir feeders: 6-foot | Douglas-fir feeders: 4-foot |
|---|---|---|---|---|---|---|---|
| Sort lumber and prerip | 1 Common | 9.30 | 11.24 | 11.67 | 7.24 | | |
| | 2 Common | 12.22 | 15.09 | 14.33 | 9.91 | | |
| | 2 Common and Poorer | 21.74 | 19.06 | 16.76 | 12.39 | | |
| Crosscut | 1 Common | 37.97 | 26.37 | 22.79 | 13.52 | | |
| | 2 Common | 57.31 | 36.84 | 32.21 | 20.54 | | |
| | 2 Common and Poorer | 96.51 | 55.91 | 40.13 | 27.30 | | |
| | C and Better | | | | | 16.83 | 12.70 |
| Surface | 1 Common | 22.61 | 26.51 | 24.23 | 13.52 | | |
| | 2 Common | 26.68 | 36.83 | 33.00 | 20.54 | | |
| | 2 Common and Poorer | 38.52 | 55.95 | 41.04 | 27.30 | | |
| Rip | 1 Common | 59.74 | 62.83 | 47.55 | 34.38 | | |
| | 2 Common | 77.55 | 71.36 | 66.15 | 40.77 | | |
| | 2 Common and Poorer | 102.09 | 116.02 | 82.01 | 54.84 | | |
| | C and Better | | | | | 2.75 | 2.10 |
| Tongue-and-groove | 1 Common | 30.13 | 21.20 | 10.53 | 12.14 | | |
| | 2 Common | 32.35 | 22.68 | 11.50 | 13.57 | | |
| | 2 Common and Poorer | 41.47 | 26.21 | 12.24 | 14.73 | | |
| All operations | 1 Common | 159.75 | 148.15 | 116.77 | 80.80 | | |
| | 2 Common | 206.11 | 182.80 | 157.29 | 105.33 | | |
| | 2 Common and Poorer | 300.33 | 273.15 | 192.18 | 136.56 | | |
| | C and Better | | | | | 19.58 | 14.80 |

1/ Productive labor only, for all feeder parts except skids and trough fronts.
2/ Four-foot oak feeders were produced by Method B.

## *LABOR REQUIRED TO PRODUCE FEEDERS*[5]

Direct labor time required to produce oak feeders (tables 2, 3, and 4) was significantly affected by production method, grade of lumber, and size of feeder. Time differences between methods and for different grades of lumber were due almost entirely to the rough-milling and tongue-and-grooving operations (table 2). A more mechanized method required fewer men and, therefore, less labor per feeder for all grades of lumber used. A higher grade of lumber, having fewer defects, required fewer decisions by cutoff and ripsawyers and gave a higher yield of feeder parts. Therefore, the higher grades required less time per feeder to rough-mill by all methods.

[5] *Direct labor time shown in this section is for productive labor only. No allowance has been made for machine or jig setup, materials handling, or downtime. See section on "What it means" for results after figuring in time for nonproductive labor.*

*TABLE 3.—Labor time to finish-mill, fabricate, assemble, and finish by feeder size, species, and lumber grade*[1]

(In man-minutes per feeder)

| Operation | Oak feeders | | | | | | Douglas-fir feeders | |
|---|---|---|---|---|---|---|---|---|
| | 6-foot | | | 4-foot | | | | |
| | No. 1 Common | No. 2 Common | No. 2 Common and Poorer | No. 1 Common | No. 2 Common | No. 2 Common and Poorer | 6-foot | 4-foot |
| Machine skids and trough fronts | 11.86 | 11.86 | 11.86 | 11.86 | 11.86 | 11.86 | 5.05 | 5.05 |
| Finish-mill | | | | | | | | |
| Angle cut | 4.12 | 4.12 | 4.12 | 3.16 | 3.16 | 3.16 | 4.12 | 3.16 |
| Dado | 1.79 | 1.79 | 1.79 | 1.63 | 1.63 | 1.63 | 1.79 | 1.63 |
| Band saw | 1.16 | 1.16 | 1.16 | .87 | .87 | .87 | 1.16 | .87 |
| Angle rip | .31 | .31 | .31 | .31 | .31 | .31 | .20 | .20 |
| Trim | 16.14 | 17.11 | 18.11 | 8.92 | 9.25 | 9.67 | -- | -- |
| Subtotal | 23.52 | 24.49 | 25.49 | 14.89 | 15.22 | 15.64 | 7.27 | 5.86 |
| Fabricate | | | | | | | | |
| Base | 20.32 | 18.55 | 18.67 | 14.46 | 14.44 | 13.99 | 15.64 | 12.05 |
| Sides | 28.15 | 28.15 | 31.32 | 18.27 | 22.90 | 23.24 | 22.43 | 15.27 |
| Ends | 24.92 | 26.07 | 28.84 | 24.92 | 26.07 | 28.84 | 19.50 | 19.50 |
| Tops | 6.21 | 6.25 | 5.64 | 4.46 | 5.20 | 5.48 | 5.09 | 4.28 |
| Partitions | 13.83 | 14.68 | 13.64 | 6.24 | 5.75 | 6.96 | 12.31 | 5.55 |
| Subtotal | 93.43 | 93.70 | 98.11 | 68.35 | 74.36 | 78.51 | 74.97 | 56.65 |
| Assemble | 36.31 | 36.31 | 36.31 | 27.30 | 27.30 | 27.30 | 36.31 | 27.30 |
| Finish | 7.16 | 7.16 | 7.16 | 3.79 | 3.79 | 3.79 | 7.16 | 3.79 |
| Attach roof sheathing and trim | 7.36 | 7.36 | 7.36 | 7.36 | 7.36 | 7.36 | 7.36 | 7.36 |
| Total | 179.64 | 180.98 | 186.29 | 133.55 | 139.79 | 144.46 | 138.12 | 106.01 |

1/ Produtive labor only.

*TABLE 4.— Total direct labor time per feeder by feeder size, production method, and lumber species and grade*[1]

| Size of feeder | Species | Method | Time unit | No. 1 Common | No. 2 Common | No. 2 Common and Poorer | C and Better |
|---|---|---|---|---|---|---|---|
| 6-foot | Oak | A | Man-minute | 339.39 | 386.99 | 486.62 | |
| | | | Man-hour | 5.66 | 6.45 | 8.11 | |
| 6-foot | Oak | B | Man-minute | 327.79 | 363.68 | 459.44 | |
| | | | Man-hour | 5.46 | 6.06 | 7.66 | |
| 6-foot | Oak | C | Man-minute | 296.41 | 338.17 | 378.47 | |
| | | | Man-hour | 4.94 | 5.64 | 6.31 | |
| 6-foot | Douglas-fir | -- | Man-minute | | | | 157.70 |
| | | | Man-hour | | | | 2.63 |
| 4-foot | Oak | B | Man-minute | 214.35 | 245.22 | 281.02 | |
| | | | Man-hour | 3.57 | 4.09 | 4.68 | |
| 4-foot | Douglas-fir | -- | Man-minute | | | | 120.81 |
| | | | Man-hour | | | | 2.01 |

1/ Productive labor only.

In method A, sheathing and flooring were tongue and grooved on a hand-fed single-spindle shaper. Use of a power feed unit on this machine in method B reduced the time per feeder 30 to 35 percent. Use of a moulder in method C reduced the method A time 65 to 70 percent and the method B time 50 percent. Thus, tongue-and-groove sheathing and flooring were produced on the moulder about twice as fast as on the power-fed shaper, and three times as fast as on the hand-fed shaper.

Since the Douglas-fir lumber was purchased surfaced four sides and tongue and grooved where necessary, it required practically no rough-milling. It was crosscut to length, and the few needed 2- by 3-inch parts were produced by ripping 2 by 6's. Thus, rough-milling time was much less for Douglas-fir feeders than for any of the oak feeders.

Parts for all feeders — both oak and Douglas-fir — were finished-milled by the same methods. There was a slight difference in total finish-milling time per feeder due to grade of oak lumber used (table 3). The difference occurred in the double-end trimming of random-width sheathing and flooring. The average width of sheathing and flooring cut from lower grade lumber was less than that of sheathing and flooring cut from higher grade lumber. Therefore, more pieces, more handling, and more time were required for feeders produced from the lower grade lumber.

The time required to fabricate panels for oak feeders differed slightly due to grade of lumber used, for the same reason that finish-milling time differed. Douglas-fir feeders required less time to fabricate because Douglas-fir was somewhat easier to nail, and the wider Douglas-fir sheathing and flooring required 10 to 13 percent fewer nails (less nailing) per feeder.

Four-foot feeders of both species required less direct labor time than six-foot feeders in all phases of production only because they required less material and, therefore, less work per feeder.

Total direct labor time (table 4) required to produce 6-foot oak feeders ranged from 4.94 man-hours to 8.11 man-hours per feeder, depending on method of rough-milling and grade of lumber used. Likewise, the time for 4-foot oak feeders ranged from 3.57 to 4.68 man-hours per feeder. Six-foot and four-foot Douglas-fir feeders were produced in 2.63 and 2.01 man-hours per feeder, respectively.

### *COST OF LUMBER AND DIRECT LABOR PER FEEDER*

The cost of lumber per feeder depends on the price of the lumber used and the yield of parts obtained. Based on yields obtained in this study, the cost of lumber per feeder (table 5) was as follows:

6-foot feeder from C and Better Douglas-fir ........ $35.60

6-foot feeder from No. 1 Common oak ........ 19.03

6-foot feeder from No. 2 Common oak ........ 15.46

6-foot feeder from No. 2 Common and Poorer oak ........ 14.14

4-foot feeder from C and Better Douglas-fir ........ 26.42

4-foot feeder from No. 1 Common oak ........ 14.51

4-foot feeder from No. 2 Common oak ........ 12.20

4-foot feeder from No. 2 Common and Poorer oak ........ 9.90

Because yield of 6-foot oak feeder parts was not affected by the method of rough-milling, the cost of lumber for these feeders is based on average yields from methods A, B, and C. Prices for oak lumber are based on July 1962 prices for southern hardwoods,[6] adjusted to apply to southern Illinois mills (table 5). Douglas-fir prices are based on those of July 1962 for KD lumber, f.o.b. mill[7] with freight added at the rate of $1.41 per hundredweight.

Cost of direct labor per feeder depends on time required to produce a feeder and hourly rate for labor. This rate will differ from shop to shop and from place to place, but we believe it will average between $1.50 and $2.00 per hour in wood processing plants in southern Illinois. Therefore, we computed direct labor costs at the two extremes of $1.50 and $2.00 per hour (table 6).

[6] *Hardwood Market Report, July 21, 1962. Copyright by Abe Lemsky, Memphis, Tennessee.*

[7] *Crow's Price Reporter, July 19, 1962. Published by C. C. Crow Publications, Inc., Portland, Oregon.*

*TABLE 5.—Cost of lumber per feeder by feeder size, species, and lumber grade*

| Species | Grade | Feeder components | 6-foot feeder | | | | | 4-foot feeder | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Volume per feeder | Yield[1] | Gross volume required | Price per thousand board feet | Cost per feeder | Volume per feeder | Yield | Gross volume required | Price per thousand board feet | Cost per feeder |
| | | | Board feet | Percent | Board feet | Dollars | Dollars | Board feet | Percent | Board feet | Dollars | Dollars |
| Oak | No. 1 Common | 3/4-inch parts | 98.2 | 71.4 | 137.5 | 73.00 | 10.04 | 72.2 | 70.6 | 102.3 | 73.00 | 7.47 |
| | | 6/4-inch parts | 47.7 | 68.2 | 69.9 | 109.00 | 7.62 | 36.0 | 64.5 | 55.8 | 109.00 | 6.08 |
| | | Skids | 4.4 | 72.8 | 6.0 | 70.00 | .42 | 3.2 | 72.8 | 4.4 | 70.00 | .31 |
| | | Trough fronts | 7.0 | 55.8 | 12.6 | 75.00 | .95 | 4.8 | 55.8 | 8.6 | 75.00 | .65 |
| | | Total | | | | | 19.03 | | | | | 14.51 |
| Oak | No. 2 Common | 3/4-inch parts | 98.4 | 60.0 | 164.0 | 52.00 | 8.53 | 72.3 | 58.8 | 123.0 | 52.00 | 6.40 |
| | | 6/4-inch parts | 47.9 | 60.3 | 79.4 | 70.00 | 5.56 | 36.0 | 52.0 | 69.2 | 70.00 | 4.84 |
| | | Skids | 4.4 | 72.8 | 6.0 | 70.00 | .42 | 3.2 | 72.8 | 4.4 | 70.00 | .31 |
| | | Trough fronts | 7.0 | 55.8 | 12.6 | 75.00 | .95 | 4.8 | 55.8 | 8.6 | 75.00 | .65 |
| | | Total | | | | | 15.46 | | | | | 12.20 |
| Oak | No. 2 Common and Poorer | 3/4-inch parts | 98.8 | 46.4 | 212.9 | 38.00 | 8.09 | 72.6 | 52.3 | 138.8 | 38.00 | 5.27 |
| | | 6/4-inch parts | 47.9 | 50.1 | 95.6 | 49.00 | 4.68 | 36.2 | 48.4 | 74.8 | 49.00 | 3.67 |
| | | Skids | 4.4 | 72.8 | 6.0 | 70.00 | .42 | 3.2 | 72.8 | 4.4 | 70.00 | .31 |
| | | Trough fronts | 7.0 | 55.8 | 12.6 | 75.00 | .95 | 4.8 | 55.8 | 8.6 | 75.00 | .65 |
| | | Total | | | | | 14.14 | | | | | 9.90 |
| Douglas-fir | C and Better | 4/4-inch parts | 108.3 | 93.2 | 116.2 | 171.79 | 19.96 | 80.0 | 93.2 | 85.8 | 171.43 | 14.71 |
| | | 8/4-inch parts | 71.2 | 89.8 | 79.3 | 173.55 | 13.76 | 53.8 | 89.8 | 59.9 | 173.68 | 10.40 |
| | | Skids | 4.4 | 72.8 | 6.0 | 70.00 | .42 | 3.2 | 72.8 | 4.4 | 70.00 | .31 |
| | | Trough fronts | 6.9 | 87.5 | 7.9 | 185.00 | 1.46 | 4.7 | 87.5 | 5.4 | 185.00 | 1.00 |
| | | Total | | | | | 35.60 | | | | | 26.42 |

1/ Yields for oak 3/4 and 6/4 are averages of Methods A, B, and C (table 1).

*TABLE 6.—Cost of lumber and direct labor per feeder by feeder size, production method, and lumber species and grade*[1]

| Size of feeder (feet) | Species | Grade | Method | Cost of lumber | Labor time | Cost of labor: $1.50 per hour | Cost of labor: $2.00 per hour | Total cost: $1.50 per hour | Total cost: $2.00 per hour |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Dollars | Man-hours | Dollars | Dollars | Dollars | Dollars |
| 6 | Oak | 1 Common | A | 19.03 | 5.66 | 8.49 | 11.32 | 27.52 | 30.35 |
| 6 | Oak | 1 Common | B | 19.03 | 5.46 | 8.19 | 10.92 | 27.22 | 29.95 |
| 6 | Oak | 1 Common | C | 19.03 | 4.94 | 7.41 | 9.88 | 26.44 | 28.91 |
| 6 | Oak | 2 Common | A | 15.46 | 6.45 | 9.68 | 12.90 | 25.14 | 28.36 |
| 6 | Oak | 2 Common | B | 15.46 | 6.06 | 9.09 | 12.12 | 24.55 | 27.58 |
| 6 | Oak | 2 Common | C | 15.46 | 5.64 | 8.46 | 11.28 | 23.92 | 26.74 |
| 6 | Oak | 2 Common and Poorer | A | 14.14 | 8.11 | 12.17 | 16.22 | 26.31 | 30.36 |
| 6 | Oak | | B | 14.14 | 7.66 | 11.49 | 15.32 | 25.63 | 29.46 |
| 6 | Oak | | C | 14.14 | 6.31 | 9.47 | 12.62 | 23.61 | 26.76 |
| 4 | Oak | 1 Common | B | 14.51 | 3.57 | 5.36 | 7.14 | 19.87 | 21.65 |
| 4 | Oak | 2 Common | B | 12.20 | 4.09 | 6.14 | 8.18 | 18.34 | 20.38 |
| 4 | Oak | 2 Common and Poorer | B | 9.90 | 4.68 | 7.02 | 9.36 | 16.92 | 19.26 |
| 6 | Douglas-fir | C and Better | - | 35.60 | 2.63 | 3.95 | 5.26 | 39.55 | 40.86 |
| 4 | Douglas-fir | C and Better | - | 26.42 | 2.01 | 3.02 | 4.02 | 29.44 | 30.44 |

1/ Cost of productive labor only, at average rates of $1.50 and $2.00 per hour.

Higher priced, higher grade lumber gave the highest lumber cost per feeder but required the least time and labor cost for conversion to feeders. Feeders from No. 1 Common oak lumber cost more than those from either No. 2 Common or No. 2 Common and Poorer oak (table 6) because the higher price of No. 1 Common oak lumber offset its advantages of greater yield and less labor.

On the other hand, the lower price of No. 2 Common and Poorer oak lumber was not low enough to offset No. 2 Common's advantages of higher yield and less labor. In most cases, No. 2 Common gave the lowest total lumber and direct labor cost per feeder. There were exceptions in method C (6-foot feeders) and in the 4-foot oak feeders where No. 2 Common and Poorer lumber gave the lowest total cost. But as explained earlier, we believe these costs are abnormally low because of unintentional upgrading of No. 3 Common in the No. 2 Common and Poorer lumber.

The total cost of wood parts and direct labor for all oak feeders, regardless of production method or grade of raw material, was significantly less than for Douglas-fir feeders. At $2.00 per hour for labor, this was 26 to 35 percent ($10.50 to $14.12) less for 6-foot feeders, depending on grade of lumber and production method used. Similarly, 4-foot oak feeders cost 29 to 37 percent ($8.79 to $11.18) less than 4-foot Douglas-fir feeders. At labor rates less than $2.00 per hour, the advantage of using oak lumber becomes greater.

### *COST OF MATERIALS OTHER THAN LUMBER*

Some materials cost the same for all feeders of a given size regardless of species or grade of lumber used. These include hardware such as bolts, nuts, and washers; metal parts, such as feed doors and feed gates; wood preservative; and finishing materials. These materials cost $32.54 for 6-foot feeders and $23.01 for 4-foot feeders (Appendix, page 38).

We purchased hardware and metal parts in small quantities from wholesale suppliers and custom metal fabricators. Quotations obtained in July 1964 indicate that these items can be purchased in larger quantities at less than half the price we paid for small quantities. Also, it is probable that the 28-gauge sheet metal parts and those parts made from flat steel bar stock could be produced at still less cost by the feeder manufacturer. In any case, these items would cost the same for feeders from any species or grade of lumber.

## WHAT IT MEANS

A comparison based only on material and productive labor costs does not tell the whole story regarding the advantage of using one type of material over another. Investment in buildings and equipment, power consumption, labor used in machine setups and materials handling, downtime, various investment- and labor-dependent costs, and rate of production must also be considered in arriving at the real difference in cost of producing hog feeders from rough, low-grade hardwood lumber and high-grade softwood finish lumber. The investment required to produce feeders from rough hardwood lumber will be greater at any rate of production. Likewise, power costs and the investment- and labor-dependent costs will be higher for hardwood feeders. The question is whether the lower cost of the lower grades of rough hardwood raw material will offset the increase in these other costs.

Raw material, processing equipment, and labor can be combined in many ways to produce feeders from oak or other hardwood lumber. Investment, rate of production, and cost per feeder would depend on how they are combined. It is impossible to analyze all possibilities here. However, using data collected in this study, we can set up efficient operations for producing feeders in reasonable numbers from both oak and Douglas-fir lumber. Then we can determine investments required and estimate total production costs using the method outlined by Coolidge and Pfeiffer.[8]

A comparison of the cost of producing feeders from No. 2 Common oak and C and Better Douglas-fir follows. The operations described are not necessarily optimum, but they are realistic and show that it is both practical and profitable to use oak lumber for this product. The following 13 assumptions were made for this comparison:

1. Size of feeder to be produced: 6-foot only, to simplify the illustration. Six-foot feeders are the most popular size produced by commercial plants. Inclusion of longer or shorter feeders would affect the number produced per unit of time and the average cost per feeder, but should not affect the comparison between species so long as the ratio of sizes produced is the same.
2. Rate of production of oak feeders: full capacity of labor and equipment, assuming that the market will absorb 5,000 to 6,000 feeders per year.
3. Rate of production of Douglas-fir feeders: full capacity of labor and equipment selected to produce at about the same rate as for oak feeders.

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[8] *Coolidge, L. D., and Pfeiffer, J. R. Cost estimating for wood industries. Oreg. Forest Prod. Lab. Inform. Cir. 9, Corvallis, Oregon, 78 pp., June 1956.*

4. Production procedure: One aim is a balanced, even flow of parts of different thickness through production, fabrication, and assembly. Another is a realistic relation between setup time, move time, and machine-operation time. To achieve both aims, lumber and feeder parts (except skids and trough fronts) will be processed in lots of 52 feeders each. For example, in producing oak feeders, the rough-mill will process 3/4 lumber for approximately 12 hours, then switch to 6/4 lumber for 4 hours. In each 16 hours of operation, this will produce enough parts of each thickness for 52 feeders. Setup and move times for all production operations will be computed on the basis of 52-feeder lots. Because skids must be sent out for pressure treatment, they will be produced intermittently in lots big enough to take care of 1,000 feeders. Trough fronts will be produced in lots big enough for at least 80 feeders (the output from 1,000 board feet of rough 16/4 lumber).

5. Storage facilities: sufficient for a 4-week supply of raw materials and 4 weeks' production of feeders.

6. Working hours: 247 work days or 1,976 hours per year. Loss of time due to work stoppages: 10 percent or 198 hours per year. Net production time: 1,778 hours per year.

7. Wage rate: $1.75 per hour.

8. Building costs: Production floor space: $4.00 per square foot. Assembly floor space: $2.00 per square foot. Storage space: $1.00 per square foot.

9. Machinery installation cost: 10 percent of delivered cost of machinery.

10. Power consumption (kilowatt hours) and cost: Annual requirements =

$$\frac{\text{total horsepower x 746}}{1{,}000}$$

x annual production hours. Cost of electric current = $0.01 per KWH

11. Investment- and labor-dependent costs:

Direct overhead (nonoperating foremen) — 10 percent of direct labor.

Payroll overhead (disability wages, vacation wages, Social Security, group insurance, and so forth) — 15 percent of direct labor.

General overhead (first aid, workmen's compensation, sanitation and janitorial expense, travel, administrative and general office overhead, and so forth) — 50 percent of direct labor.

Maintenance — 4 percent of physical plant cost.

Depreciation — Buildings, 5 percent; machinery, 10 percent; small tools, 20 percent.

Taxes and insurance — 3 percent of physical plant cost.

12. Selling price of feeders: $100.00 per feeder.

13. Selling and management costs: 5 percent of sales.

### *PLANT SETUP FOR PRODUCTION OF FEEDERS FROM NO. 2 COMMON OAK LUMBER*

Analysis of the methods used to rough-mill oak lumber in this study showed that, considering equipment costs and depreciation; in-

terest, taxes, and insurance on the average investment; maintenance costs; production rate; and labor cost per unit of production, method B gave the lowest cost of production at rates between 1,500 and 8,000 feeders per year. Similarly, the single-spindle shaper with power feed gave lower tongue-and-grooving costs than the moulder at production rates up to 8,000 feeders per year. Therefore, a modification of method B, and a power-fed shaper were selected for rough-milling and tongue-and-grooving parts for oak feeders in this illustration.

Production equipment consists of two pneumatic or hydraulic cutoff saws feeding, via conveyors, to a double planer or facer planer (table 7). Material is taken from the planer, on factory trucks or skids, to two straight-line ripsaws, and then to the shaper, table saw, band saw, or radial saw as required for finish-milling. The roll-feed ripsaw is used to prerip oak lumber, and the jointer is used to surface trough fronts. Various portable electric tools are required for fabricating and assembling which are done by separate crews in an assembly area.

Equipment costs are based on 1963 prices of new, heavy-duty woodworking machines of the type we used to produce feeders (table 7). Prices of individual machines will vary according to size, model, and manufacture. In some cases, smaller or cheaper models would suffice for production of feeders. Therefore, we believe equipment costs allowed for in this example are ample.

Based on yield from No. 2 Common oak lumber, machine- and man-hours (adjusted for setups and movement of material) obtained in the production study, and the listed assumptions, this plant could produce 5,646 feeders per year. Twenty-five men would be required as follows:

Rough-mill, including sorting and preripping ...... 9 men

Finish-mill, including tongue and grooving ........... 4 men

Fabrication, assembly, and finishing ........................ 9 men

Forklift operation and materials handling .............. 3 men

Estimated space requirements would be:

Production floor space .................... 6,000 square feet

Fabrication floor space .................... 4,000 square feet

Lumber and product storage space ... 6,800 square feet

This plant would require approximately 6,000 board feet of lumber per day or 1.5 million board feet per year. This is the approximate output of two 16,000-board-feet-per-day sawmills producing 90 percent oak, 20 percent of which is No. 2 Common.

*TABLE 7.—Equipment required to produce feeders from oak lumber*

| Item | Number required | Total horsepower | Delivered cost (each) | Total cost |
|---|---|---|---|---|
| | | | Dollars | Dollars |
| Machinery: | | | | |
| Automatic cutoff saw (pneumatic or hydraulic) | 2 | 15.00 | 2,000 | 4,000 |
| Cross-feed conveyor (cutoff saw) | 2 | 1.50 | 1,000 | 2,000 |
| Belt conveyor (cutoff saw to planer) | 1 | .75 | 1,350 | 1,350 |
| Surfacer (double planer or facer planer) | 1 | 33.00 | 15,000 | 15,000 |
| Straight-line ripsaw | 2 | 36.00 | 4,000 | 8,000 |
| Roll-feed ripsaw | 1 | 18.00 | 3,000 | 3,000 |
| Shaper, single-spindle | 1 | 5.00 | 2,300 | 2,300 |
| Power-feed unit (shaper) | 1 | .75 | 650 | 650 |
| Jointer, 16-inch | 1 | 5.00 | 1,750 | 1,750 |
| Band saw, 30-inch | 1 | 3.00 | 2,380 | 2,380 |
| Table saw, 16-inch tilting arbor | 1 | 5.00 | 1,800 | 1,800 |
| Radial saw, 16-inch | 1 | 5.00 | 800 | 800 |
| Subtotal | | | | 43,030 |
| Installation (10 percent of delivered cost) | | | | 4,303 |
| Total | | | | 47,333 |
| Small tools: | | | | |
| 3/8-inch electric drill | 3 | | 70 | 210 |
| 1/4-inch electric drill | 3 | | 50 | 150 |
| 6 1/2-inch portable circular saw | 3 | | 65 | 195 |
| Electric nut runner (3/8-inch nut) | 1 | | 125 | 125 |
| Electric screwdriver (No. 12 wood screw) | 1 | | 125 | 125 |
| Total | | | | 805 |
| Forklift truck (3-ton) | 1 | | 6,000 | 6,000 |
| Total - all equipment | | | | 54,138 |

## PLANT SETUP FOR PRODUCTION OF FEEDERS FROM C AND BETTER DOUGLAS-FIR LUMBER

Equipment required to produce feeders from C and Better Douglas-fir lumber at approximately the same rate and level of efficiency as described for oak feeders consists of two radial saws and a surfacer, ripsaw, table saw, and band saw (table 8). Portable tool requirements are the same as for oak feeders.

Based on our experience in producing Douglas-fir feeders and on the listed assumptions this plant could produce 6,358 six-foot feeders per year. Seventeen men would be required as follows:

| | |
|---|---|
| Rough-mill and finish-mill | 4 men |
| Fabrication, assembly, and finishing | 10 men |
| Forklift operation and materials handling | 3 men |

Estimated space requirements would be:

| | |
|---|---|
| Production floor space | 3,000 square feet |
| Fabrication and assembly space | 4,000 square feet |
| Lumber and product storage space | 7,000 square feet |

This plant would require approximately 5,400 board feet of lumber per day or 1.3 million board feet per year, including 38,200 board feet of No. 2 Common oak lumber for skids.

## COMPARISON OF INVESTMENT, COST OF PRODUCTION, AND ESTIMATED PROFIT

The total investment in buildings and equipment required to produce feeders is $92,938 for the plant using No. 2 Common red oak lumber and $53,363 for the plant using C and Better Douglas-fir (table 9).[9] Production costs, including raw materials, power, and all labor- and investment-dependent costs, would be $77.56 per feeder for oak (table 10) and $85.67 per feeder for Douglas-fir (table 11). Assuming a selling price of $100.00 per feeder, and selling and management expenses equal to 5 percent of sales, estimated annual profit (before income taxes) from production of feeders would be $98,436.55 for oak feeders and $59,381.64 for Douglas-fir feeders (table 12). Profit per dollar invested would be $1.06 for oak and $1.11 for Douglas-fir feeders, and profit per sales dollar would be $0.17 for oak and $0.09 for Douglas-fir.

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[9] *These costs include all but a few items of equipment such as factory trucks or skids, jigs, treating equipment, and finishing equipment that would have a minor effect on cost per feeder and, in any case, would be the same for feeders of both species.*

*TABLE 8. — Equipment required to produce feeders from Douglas-fir lumber*

| Item | Number required | Total horsepower | Delivered cost (each) | Total cost |
|---|---|---|---|---|
| | | | Dollars | Dollars |
| Machinery: | | | | |
| Radial saw, 16-inch | 2 | 10 | 800 | 1,600 |
| Surfacer, single, 30-inch | 1 | 18 | 9,000 | 9,000 |
| Roll-feed ripsaw | 1 | 18 | 3,000 | 3,000 |
| Table saw, 16-inch tilting arbor | 1 | 5 | 1,800 | 1,800 |
| Band saw, 30-inch | 1 | 3 | 2,380 | 2,380 |
| Subtotal | | | | 17,780 |
| Installation (10 percent of delivered cost) | | | | 1,778 |
| Total | | | | 19,558 |
| Small tools: | | | | |
| 3/8-inch electric drill | 3 | | 70 | 210 |
| 1/4-inch electric drill | 3 | | 50 | 150 |
| 6 1/2-inch portable circular saw | 3 | | 65 | 195 |
| Electric nut runner (3/8-inch nut) | 1 | | 125 | 125 |
| Electric screwdriver (No. 12 wood screw) | 1 | | 125 | 125 |
| Total | | | | 805 |
| Forklift truck, 3-ton | 1 | | 6,000 | 6,000 |
| Total - all equipment | | | | 26,363 |

*TABLE 9.—Estimated physical plant costs for production of feeders from red oak and Douglas-fir lumber*

| Item | Red oak | Douglas-fir |
|---|---|---|
| | Dollars | Dollars |
| Buildings: | | |
| Production area | 24,000 | 12,000 |
| Fabrication and assembly area | 8,000 | 8,000 |
| Storage area | 6,800 | 7,000 |
| Total building costs | 38,800 | 27,000 |
| Process equipment: | | |
| Machinery, including forklift truck | 53,333 | 25,558 |
| Small tools | 805 | 805 |
| Total equipment costs | 54,138 | 26,363 |
| Total physical plant costs | 92,938 | 53,363 |

*TABLE 10.—Estimated production cost of feeders from No. 2 Common red oak lumber*

| Item | Factor or rate per unit | Amount required | Annual cost | Cost per feeder |
|---|---|---|---|---|
| | | Units | Dollars | Dollars |
| Raw materials: | | | | |
| Lumber | $15.46 per feeder | 5,646 | 87,287.16 | 15.46 |
| Metal, hardware, etc. | $32.54 per feeder | 5,646 | 183,720.84 | 32.54 |
| Total materials | | | 271,008.00 | 48.00 |
| Power | $0.01 per KWH | 169,799 | 1,697.99 | 0.30 |
| Labor-dependent costs: | | | | |
| Direct labor | $1.75 per man-hour | 49,400 | 86,450.00 | 15.31 |
| Direct overhead | 10% of direct labor | | 8,645.00 | 1.53 |
| Payroll overhead | 15% of direct labor | | 12,967.50 | 2.30 |
| General overhead | 50% of direct labor | | 43,225.00 | 7.66 |
| Total labor-dependent costs | | | 151,287.50 | 26.80 |
| Investment-dependent costs: | | | | |
| Maintenance | 4% of physical plant cost | | 3,717.52 | 0.66 |
| Depreciation - buildings | 5% of building cost | | 1,940.00 | .34 |
| Depreciation - Machinery | 10% of machinery cost | | 5,333.30 | .94 |
| Depreciation - small tools | 20% of tool cost | | 161.00 | .03 |
| Taxes and insurance | 3% of physical plant cost | | 2,788.14 | .49 |
| Total investment-dependent costs | | | 13,939.96 | 2.46 |
| Total production cost | | | 437,933.45 | 77.56 |

*TABLE 11.—Estimated production cost of feeders from C and Better Douglas-fir lumber*

| Item | Factor or rate per unit | Amount required | Annual cost | Cost per feeder |
|---|---|---|---|---|
| | | Units | Dollars | Dollars |
| Raw materials: | | | | |
| Lumber | $35.60 per feeder | 6,358 | 226,344.80 | 35.60 |
| Metal, hardware, etc. | $32.54 per feeder | 6,358 | 206,889.32 | 32.54 |
| Total materials | | | 433,234.12 | 68.14 |
| Power | $0.01 per KWH | 71,653 | 716.53 | 0.11 |
| Labor-dependent costs: | | | | |
| Direct labor | $1.75 per man-hour | 33,592 | 58,786.00 | 9.25 |
| Direct overhead | 10% of direct labor | | 5,878.60 | .93 |
| Payroll overhead | 15% of direct labor | | 8,817.90 | 1.39 |
| General overhead | 50% of direct labor | | 29,393.00 | 4.62 |
| Total labor-dependent costs | | | 102,875.50 | 16.19 |
| Investment-dependent costs: | | | | |
| Maintenance | 4% of physical plant cost | | 2,134.52 | 0.34 |
| Depreciation - buildings | 5% of building cost | | 1,350.00 | .21 |
| Depreciation - machinery | 10% of machinery cost | | 2,555.80 | .40 |
| Depreciation - small tools | 20% of tool cost | | 161.00 | .03 |
| Taxes and insurance | 3% of physical plant cost | | 1,600.89 | .25 |
| Total investment-dependent costs | | | 7,802.21 | 1.23 |
| Total production cost | | | 544,628.36 | 85.67 |

*TABLE 12.—Estimated profit from production of hog feeders from No. 2 Common red oak and C and Better Douglas-fir lumber*

| Item | Red oak feeders 1/ | Douglas-fir feeders 2/ |
|---|---|---|
| | Dollars | Dollars |
| Total plant investment | 92,938.00 | 53,363.00 |
| Expected selling price per feeder | 100.00 | 100.00 |
| Annual sales | 564,600.00 | 635,800.00 |
| Annual operating costs: | | |
| Production | 437,933.45 | 544,628.36 |
| Selling and management 3/ | 28,230.00 | 31,790.00 |
| Total operating costs | 466,163.45 | 576,418.36 |
| Net annual profit before income taxes | 98,436.55 | 59,381.64 |
| Profit per invested dollar | 1.06 | 1.11 |
| Profit per sales dollar | .17 | .09 |
| Profit per feeder (profit margin) | 17.43 | 9.34 |

1/ Annual production--5,646 feeders.
2/ Annual production--6,358 feeders.
3/ 5 percent of sales.

## *USE OF OTHER GRADES OF OAK LUMBER*

A plant using No. 1 Common or No. 2 Common and Poorer oak lumber to produce feeders would require about the same processing equipment as one using No. 2 Common. But labor requirements would be different and output would be higher in one case and lower in the other because capacity of the plant depends on the capacity of the rough-mill to convert rough lumber into feeder parts.

Substituting No. 1 Common and No. 2 Common and Poorer for No. 2 Common oak in the preceding example, we find the following:

| | *No. 1 Common* | *No. 2 Common and Poorer* |
|---|---|---|
| Plant investment (dollars) | 97,088.00 | 91,853.00 |
| Number of men (direct labor) | 28 | 20 |
| Annual production (feeders) | 7,258 | 4,046 |
| Annual lumber requirements (MM board feet) | 1.64 | 1.32 |
| Production cost (dollars per feeder) | 77.18 | 79.94 |
| Net annual profit before taxes (dollars) | 129,374.56 | 60,959.50 |
| Profit per invested dollar (dollars) | 1.33 | .66 |
| Profit per sales dollar (dollars) | .18 | .15 |
| Profit per feeder (dollars) | 17.83 | 15.07 |

# DISCUSSION

A selling price of $100 per 6-foot feeder is reasonable and competitive with that of similar wooden feeders now on the market. However, it is used here for illustration only and is not a recommended selling price. We believe several costs in this analysis could be reduced in practice, chiefly cost of metal parts and hardware. A reduction in this cost would be reflected directly in the production cost of feeders from both kinds of wood. Machinery costs might also be reduced and, obviously, this would work in favor of oak feeders. At a given level of production, certain requirements should be about the same whether a plant uses oak or Douglas-fir lumber. These are travel incident to production, janitorial expense, stockroom operating expense, utilities (except power), and administrative and general office overhead. Therefore, we believe the general overhead cost for producing oak feeders (table 10) should more nearly equal that for producing softwood feeders (table 11). Reducing any of these costs would permit a lower price for the feeders.

But whether or not these costs can be reduced, hog feeders can be produced at lower cost from any of the three grades of oak lumber studied than from high-grade softwood lumber now commonly used. Use of rough oak lumber requires greater investment in physical plant, more labor, and higher related costs. But due to the wide spread in lumber prices, oak will return a greater profit per feeder and greater net annual profit at a given rate of production.

Capacity of a plant will differ with grade of oak lumber used. Assuming one-shift operation, about 4,050 six-foot feeders could be produced from No. 2 Common and Poorer oak annually, 5,650 from No. 2 Common oak, or 7,250 from No. 1 Common oak. At the high rate of production, No. 1 Common lumber gives a slightly lower production cost and higher profit per feeder than No. 2 Common lumber. But this advantage would be eliminated at lower rates of production.

A plant capable of producing 4,000 six-foot feeders per year would be a large operation compared to those now producing wooden feeders. Thus, markets may dictate rate of production. It is both practical and profitable to use No. 2 Common and Poorer oak lumber to produce up to 4,050 six-foot feeders a year. Feeders could be produced in fewer numbers with simpler, lower cost equipment than that used in the foregoing example, but costs and profits would not be the same.

The important point is that feeders and other small farm structures can be profitably produced from No. 2 Common and Poorer hardwood lumber for which few other markets exist. Establishments of small industries based on this low-grade raw material would benefit forest landowners and forest managers, as well as sawmill operators. Hardwood resources are generally located in rural areas and such industries could contribute greatly to the economy of adjacent small communities.

# APPENDIX

## *Equipment Used to Produce Feeders*

**Method A (oak)**

1—Swinging cutoff saw, 3 hp., 14-inch saw
1—Single-surface cabinet planer, 15 hp., 30-inch capacity
1—Straight-line ripsaw, 20 hp., 14-inch carbide-tipped saw
1—Single-spindle shaper, 5 hp., 8,500 to 11,600 r.p.m.

**Method B (oak)**

1—Straight-line cutoff saw, 7½ hp., hydraulically operated, 18-inch saw; with live-roll outfeed conveyor
1—Facing planer, 10 hp., 24-inch capacity; with outfeed belt conveyor
1—single-surface cabinet planer, 15 hp., 30-inch capacity
1—Straight-line ripsaw, 20 hp., 14-inch carbide-tipped saw
1—Single-spindle shaper, 5 hp., 8,500 to 11,600 r.p.m.; with Ekstrom-Carlson Model 26C power feed unit, ¾ hp., feed rate 5 to 100 f.p.m.

**Method C (oak)**

Cutoff saw, facing planer, and cabinet planer as in Method B
Cabinet planer with outfeed belt conveyor
2—Straight-line ripsaws, 20 hp., 14-inch carbide-tipped saws; with outfeed tailboy conveyors and revolving sorting table
1—Moulder, 20 hp. (top and bottom), 10 hp. (sides), 4- by 8-inch capacity, feed rate 25 to 225 f.p.m.

**Rough-mill Douglas-fir**

1—Radial-arm saw, 5 hp., 18-inch saw
1—Straight-line ripsaw, 20 hp., 14-inch carbide-tipped saw

**Both species, all methods**

In addition, the following equipment was used in finish-milling, assembling, and finishing all feeders:
1—Forklift truck, 3-ton capacity
1—Hand jointer, 5 hp., 16-inch capacity
1—Radial-arm saw, 5 hp., 18-inch saw
1—Table saw, 7½ hp., tilting arbor, 16-inch saw
1—Band saw, 3 hp., 30-inch wheel
12—Factory trucks (hand trucks)
1—Dip treating tank
1—Paint spray booth
Miscellaneous hand tools such as electric drills, hammers, mechanical clamps, screwdrivers, and wrenches

Bill of materials for 6-foot hog feeder[1]/

BASE

| Part No. | Name | Quantity | Length | Width | Thickness | Remarks |
|---|---|---|---|---|---|---|
| 1 | Skid | 2 | 69 3/4 (49 3/4) | 3 5/8 | 1 5/16 | Chamfer ends |
| 2 | Flooring | 62 5/8" of width (42 5/8" of width) | 36 | Random | 1 5/16 | Tongue-and-groove |
| 3 | Trough front | 1 | 62 1/2 (42 1/2 | 3 3/4 | 3 3/4 | Rip to make 2 pieces per drawing |
| 4 | Trough separator | 4 (3) | 26 | 7 1/4 | 9/16 | Cut per drawing |
| 5 | Towing bracket | 1 | 14 1/2 | 1 | 1/8 | Flat steel-bar stock per drawing |
| 6 | Machine bolt | 2 | 2 | 3/8 dia. | | Towing bracket to base w/nut & 2 washers |

SIDES

| Part No. | Name | Quantity | Length | Width | Thickness | Remarks |
|---|---|---|---|---|---|---|
| 7 | Longitudinal cleat | 4 | 62 1/2 (42 1/2) | 2 5/8 | 1 5/16 | |
| 8 | Sheathing | 125 1/4" of width (85 1/4" of width) | 38 | Random | 9/16 | Tongue-and-groove |
| 9 | Sideboard | 2 | 63 3/4 (43 3/4) | 7 | 9/16 | |
| 10 | Filler | 1 | 62 5/8 (42 5/8) | 1 5/8 | 9/16 | Rip per drawing |
| 11 | Vertical cleat | 4 (2) | 38 | 1 5/8 | 9/16 | |
| 12 | Carriage bolt | 8 | 3 3/4 | 3/8 dia. | | Sides to ends; w/nut and washer |
| 13 | Tie rod | 2 (1) | 32 1/4 | 1/4 dia. | | Steel; thread ends; w/2 nuts and washers |
| 14 | Tie rod | 2 (1) | 18 1/4 | 1/4 dia. | | Steel; thread ends; w/2 nuts and washers |
| 15 | Tie rod | 2 (1) | 38 | 1/4 dia. | | Steel; thread ends; w/2 nuts and washers |
| 16 | Bearing plate | 4 (2) | 3 | 3 | 1/8 | Flat steel-bar stock per drawing |
| 17 | Feed door | 12 (8) | 13 3/16 | 9 1/2 | 16 ga. | Galvanized steel per drawing |
| 18 | Hinge rod | 2 | 62 1/4 (42 1/4) | 1/4 dia. | | Steel |
| 19 | Wide channel | 4 | 13 1/8 | 2 1/4 | 16 ga. | Galvanized steel per drawing |
| 20 | Narrow channel | 10 (4) | 13 1/8 | 1 1/2 | 16 ga. | Galvanized steel per drawing |
| 21 | Steel clip | 14 (8) | 1 7/16 | 15/32 | 1/8 | Flat steel-bar stock per drawing |
| 22 | Machine bolt | 14 (8) | 1 | 1/4 dia. | | Channel to side; w/nut and washer |
| 23 | Wood screw | 14 (8) | 1 | No. 12 | | Channel to trough front; roundhead cadmium plated |
| 24 | Feed gate | 6 (4) | 19 3/4 | 5 1/2 | 16 ga. | Galvanized steel per drawing |
| 25 | Carriage bolt | 12 (8) | 1 1/4 | 1/4 dia. | | Feed gate to side; galvanized; w/wing nut and washer |
| 26 | Corner bracket | 4 | 7 | 3 | 28 ga. | Galvanized steel per drawing |

ENDS

| | | | | | | |
|---|---|---|---|---|---|---|
| 27 | Sheathing | 72" of width | 46 11/16 | Random | 9/16 | Tongue-and-groove |
| 28 | Cleat | 2 | 36 | 3 5/8 | 1 5/16 | |
| 29 | Cleat | 2 | 36 | 2 | 1 5/16 | |
| 30 | V-cleat | 4 | 32 | 2 5/8 | 1 5/16 | Cut per drawing |
| 31 | Carriage bolt | 4 | 3 1/4 | 3/8 dia. | | Ends to base; w/nut and washer |
| 32 | Rubbing strip | 4 | 24 | 2 1/16 | 28 ga. | Galvanized steel per drawing |

TOP

| | | | | | | |
|---|---|---|---|---|---|---|
| 33 | Header | 2 | 67 1/8 (47 1/8) | 3 5/8 | 9/16 | |
| 34 | Rafter | 2 | 37 3/4 | 5 5/8 | 1 5/16 | Cut per drawing |
| 35 | Rafter | 2 (1) | 37 3/4 | 3 5/8 | 1 5/16 | Cut per drawing |
| 36 | Stringer | 1 | 67 1/8 (47 1/8) | 1 5/8 | 9/16 | |
| 37 | Cleat | 2 | 18 | 1 5/8 | 9/16 | |
| 38 | Sheathing | 1 | 69 1/8 (49 1/8) | 41 1/8 | 28 ga. | Galvanized steel per drawing |
| 39 | Long hinge | 2 | 20 3/4 | 1 | 1/8 | Flat steel-bar stock per drawing |
| 40 | Short hinge | 2 | 7 | 1 | 1/8 | Flat steel-bar stock per drawing |
| 41 | Carriage bolt | 4 | 2 1/4 | 3/8 dia. | | W/nut and 3 washers |
| 42 | Machine bolt | 4 | 2 3/4 | 3/8 dia. | | W/nut and 3 washers |
| 43 | Corner bracket | 4 | 3 1/2 | 3 | 28 ga. | Galvanized steel per drawing |
| 44 | Door pull | 1 | 7 | | | Japanned; 4-inch inside handle |
| 45 | Carriage bolt | 2 | 1 | 1/4 dia. | | W/nut and washer |

PARTITIONS

| | | | | | | |
|---|---|---|---|---|---|---|
| 46 | Sheathing | 81 5/8" of width (40 13/16" of width) | Random | Random | 9/16 | Tongue-and-groove |
| 47 | Cleat | 4 (2) | 44 | 2 5/8 | 9/16 | Cut per drawing |
| 48 | Agitator support | 1 | 62 5/8 (42 5/8) | 1 5/8 | 9/16 | |
| 49 | Agitator | 6 (4) | 93 | 3/8 dia. | | Round steel; cut and weld per drawing |
| 50 | Eye bolt | 6 (4) | 3 | 1/4 dia. | | Galvanized, w/2 nuts and washers |
| 51 | Chain | 6 (4) | 12 | | | Galvanized, No. 3 nondetachable link |

1/ Figures in parentheses are quantities or dimensions of parts for 4-foot feeder.

## *Specifications*

### Quality of Finished Wooden Parts

1. Parts joined to hold feed, including sheathing of sides, ends, and partitions; flooring; sideboards (9)*, and trough separators; and parts that are exposed (important from standpoint of appearance) including headers and end rafters (34) of the top.
   - 1.1 Prohibited defects. Parts shall be sound and free from wane, splits, knot holes, or any other holes that extend clear through the piece, rot, warp, exposed pith, shake, and slope of grain in excess of 1 inch in 10 inches along the grain. Permissible defects shall be so located as not to interfere with prescribed nailing or bolting.
   - 1.2 Permissible defects. Intergrown knots up to 1¼ inch maximum diameter and knot clusters up to 2 inches maximum diameter shall be permitted. In narrow pieces, knots and knot clusters shall not exceed one-third and one-half the width of the piece, respectively. Maximum-size knots shall be no closer than 12 inches, center to center, in any one board, and the sum of all knots in any 12 inches of length shall not exceed one and one-half times the maximum-size knot.

     Pin, shot, and spot wormholes up to ¼ inch in diameter shall be permitted on only one face of the piece. Defects such as burls, stain, streak, spot, season checks, and enclosed pith, that do not materially weaken the piece or detract from its appearance when painted, shall be permitted.
   - * Numbers in parentheses are part numbers shown in Bill of Materials.
   - 1.3 Tongue and grooving. All parts that require a tongue and groove on their edges shall have at least ½ inch of clear wood on each edge along their entire length.
2. Structural members including longitudinal cleats (7), end cleats (29), and V cleats (30).
   - 2.1 Prohibited defects shall be the same as described in paragraph 1.1.
   - 2.2 Permissible defects. Intergrown knots, knot clusters, or series of knots up to one-fourth the width of the piece shall be permitted. Maximum-size knots shall be no closer than 12 inches, center to center, in any one piece. The sum of all knots in any 12 inches of length shall not exceed one and one-half times the maximum-size knot.

     Pin, shot, and spot wormholes up to one-fourth inch in diameter shall be permitted on only one face of the piece. Defects such as burls, stain, streak, spot, season checks, and enclosed pith, that do not materially weaken the piece or detract from its appearance when painted, shall be permitted.
3. Trough front (3). Paragraphs 1.1 and 1.2 shall apply to this part except that knot size shall not be limited so long as knots are sound and intergrown.

4. All other parts including skids, rafters (35), and miscellaneous fillers, stringers, and cleats. Any defect that would not materially weaken them or interfere with prescribed nailing or bolting will be permitted in these pieces with one limitation: encased knots or knot holes exceeding ½ inch in diameter or one-fourth the width of the piece, whichever is smaller, shall be prohibited.

Cost per feeder of materials other than lumber

HARDWARE

| Part No.1/ | Item | Unit | Quantity per feeder: 6-foot | Quantity per feeder: 4-foot | Unit price | Cost per feeder: 6-foot | Cost per feeder: 4-foot |
|---|---|---|---|---|---|---|---|
| | | | Units | Units | Dollars | Dollars | Dollars |
| 6 | Machine bolt | Each | 2 | 2 | 0.030 | 0.060 | 0.060 |
| 12 | Carriage bolt | Each | 8 | 8 | .041 | .328 | .328 |
| 13 | Tie rod | Feet | 6 | 3 | .022 | .132 | .066 |
| 14 | Tie rod | Feet | 3 | 1.5 | .022 | .066 | .033 |
| 15 | Tie rod | Feet | 6.5 | 3.25 | .022 | .143 | .072 |
| 18 | Hinge rod | Feet | 10.5 | 7 | .022 | .231 | .154 |
| 22 | Machine bolt | Each | 14 | 8 | .012 | .168 | .096 |
| 23 | Wood screw | Each | 14 | 8 | .008 | .112 | .064 |
| 25 | Carriage bolt | Each | 12 | 8 | 3/ .037 | .444 | .296 |
| 31 | Carriage bolt | Each | 4 | 4 | .038 | .152 | .152 |
| 41 | Carriage bolt | Each | 4 | 4 | .033 | .132 | .132 |
| 42 | Carriage bolt | Each | 4 | 4 | .038 | .152 | .152 |
| 44 | Door pull | Each | 1 | 1 | .190 | .190 | .190 |
| 45 | Machine bolt | Each | 2 | 2 | .012 | .024 | .024 |
| 49 | Agitator 2/ | Feet | 48 | 32 | .041 | 4/ 4.968 | 5/ 3.312 |
| 50 | Eye bolt 2/ | Each | 6 | 4 | .032 | .192 | .128 |
| 51 | Chain 2/ | Feet | 6 | 4 | .060 | .360 | .240 |
| | Total | | | | | 7.85 | 5.50 |

METAL PARTS

| Part No. | Item | Unit | 6-foot | 4-foot | Unit price | 6-foot | 4-foot |
|---|---|---|---|---|---|---|---|
| 5 | Tow bracket | Each | 1 | 1 | 1.07 | 1.07 | 1.07 |
| 16 | Bearing plate | Each | 4 | 2 | .11 | .44 | .22 |
| 17 | Feed door | Each | 12 | 8 | .52 | 6.24 | 4.16 |
| 19 | Wide channel | Each | 4 | 4 | .39 | 1.56 | 1.56 |
| 20 | Narrow channel | Each | 10 | 4 | .37 | 3.70 | 1.48 |
| 21 | Steel clip | Each | 14 | 8 | .11 | 1.54 | .88 |
| 24 | Feed gate | Each | 6 | 4 | .59 | 3.54 | 2.36 |
| 26 | Corner bracket | Each | 4 | 4 | .09 | .36 | .36 |
| 32 | Rub strip | Each | 4 | 4 | .16 | .64 | .64 |
| 38 | Sheathing | Each | 1 | 1 | | 2.53 | 1.90 |
| 39 | Long hinge | Each | 2 | 2 | .20 | .40 | .40 |
| 40 | Short hinge | Each | 2 | 2 | .18 | .36 | .36 |
| 43 | Corner bracket | Each | 4 | 4 | .08 | .32 | .32 |
| | Total | | | | | 22.70 | 15.71 |

1/ See Bill of Materials, page , for complete description.
2/ Optional equipment; agitators supplied on order.
3/ Includes galvanized or cadmium-plated wing nut.
4/ Includes $3.00 per feeder for welding six agitators.
5/ Includes $2.00 per feeder for welding four agitators.

## NAILS

| Species of lumber | Grade of lumber | Size and type of nail[1] | Nails per feeder: 6-foot | Nails per feeder: 4-foot | Cost per feeder: 6-foot | Cost per feeder: 4-foot |
|---|---|---|---|---|---|---|
| | | | Number | Number | Dollars | Dollars |
| Oak | No. 1 Common | 7D screw | 106 | 75 | 0.190 | 0.134 |
| | No. 2 Common | nail[2] | 103 | 75 | .184 | .134 |
| | No. 2 Common & Poorer | | 113 | 79 | .202 | .141 |
| Douglas-fir | C & Better | | 105 | 74 | .188 | .133 |
| Oak | No. 1 Common | 1 1/8-inch | 174 | 115 | .141 | .093 |
| | No. 2 Common | screw nail[3] | 173 | 112 | .140 | .091 |
| | No. 2 Common & Poorer | | 170 | 116 | .138 | .094 |
| Douglas-fir | C & Better | | 152 | 104 | .123 | .084 |
| Oak | No. 1 Common | 1 1/2-inch | 134 | 129 | .184 | .176 |
| | No. 2 Common | screw nail[4] | 136 | 131 | .186 | .179 |
| | No. 2 Common & Poorer | | 142 | 137 | .195 | .187 |
| Douglas-fir | C & Better | | 123 | 119 | .168 | .163 |
| Oak | No. 1 Common | 4D Common[5] | 169 | 122 | .070 | .051 |
| | No. 2 Common | | 175 | 123 | .073 | .051 |
| | No. 2 Common & Poorer | | 181 | 126 | .075 | .052 |
| Douglas-fir | C & Better | | 149 | 104 | .062 | .043 |
| Oak | No. 1 Common | All | 583 | 441 | .585 | .454 |
| | No. 2 Common | nails | 587 | 441 | .583 | .455 |
| | No. 2 Common & Poorer | | 606 | 458 | .610 | .474 |
| Douglas-fir | C & Better | | 529 | 401 | .541 | .423 |

1/ All screw nails supplied by Independent Nail Corporation, Bridgewater, Massachusetts.

2/ 7D, Screwtite flooring nail, blunt-point, hardened steel, galvanized; 27 cents per pound, 151 nails per pound.

3/ 1 1/8-inch, 16-gauge, Screwtite nail, blunt-point, hardened steel, galvanized; 56 cents per pound, 692 nails per pound.

4/ 1 1/2-inch, 14-gauge, Screwtite nail, blunt-point, hardened steel, galvanized; 48 cents per pound, 350 nails per pound.

5/ 4D Common bright nail, diamond-point; 13 cents per pound, 315 nails per pound.

## WOOD PRESERVATIVE

| | Cost per feeder 6-foot | Cost per feeder 4-foot |
|---|---|---|
| | Dollars | Dollars |
| Commercial pressure treatment of skids with 5 percent pentachlorophenol to 6 pounds per cubic foot retention at $55.00 per million board feet | 0.24 | 0.18 |
| Dip or soak treatment of all other feeder parts in 5 percent pentachlorophenol in mineral spirits. Approximately 1.9 gallons preservative per feeder at $0.464 per gallon | .88 | .88 |
| Total preservative | 1.12 | 1.06 |

## FINISHING MATERIALS

| | | |
|---|---|---|
| Approximately 1 pint FPL Natural Finish per feeder at $0.29 per pint | 0.29 | 0.29 |

## TOTAL MATERIALS OTHER THAN LUMBER

| | | |
|---|---|---|
| Hardware | 7.85 | 5.50 |
| Metal parts[1] | 22.70 | 15.71 |
| Nails (average) | .58 | .45 |
| Wood preservative | 1.12 | 1.06 |
| Finishing materials | .29 | .29 |
| Total | 32.54 | 23.01 |

1/ Including agitators. Deduct $5.52 and $3.68, respectively, for 6-foot and 4-foot feeders without agitators.